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Report of the On-Site Inspection Workshop-5 Planning and Examination of Inspection Phases

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**PREPARATORY COMMISSION FOR
THE COMPREHENSIVE NUCLEAR-
TEST-BAN TREATY ORGANIZATION**

DRAFT

REPORT OF THE ON-SITE INSPECTION WORKSHOP-5
- Planning and Examination of Inspection Phases

Farnborough, United Kingdom, 8-12 November 1999

Head of Organizing Committee:
Vladimir Krioutchenkov

Co-Chairmen:
Vitaliy Shchukin, Alwyn Davies

Rapporteur:
Jerry J. Sweeney

EXECUTIVE SUMMARY

On-Site Inspection (OSI) Workshop-5 met 8-12 November, 1999 in Farnborough, U.K. and was hosted by the Defence Evaluation and Research Agency (DERA). The purpose of the workshop was to provide guidance on OSI Operational Manual (OM) development for Working Group B (WGB) of the CTBT Preparatory Commission (PrepCom). The two main topics of the workshop involved logistics/preparatory activities for the pre-inspection phase and in-depth examination of technology application during the initial and continuation phases of an OSI.

Reports from the PTS-sponsored Kazakhstan OSI experiment set the tone for the discussions of logistics and preparatory activities. The most important recommendation coming out of the experiment and workshop discussions is a need for Working Group A to develop specific administrative and financial rules regarding OSIs and define the status of inspectors and inspector assistants with respect to the CTBTO. There was also extensive discussion of a need for Working Group B to develop and/or adapt safety standards. With respect to OSI preparations, the group agreed that the time line and quick response required by an OSI necessitate development of special procedures; standing arrangements and/or advanced parties are suggested as one possible approach and a list of relevant issues has been initiated. A chart was developed that outlines the various elements of logistics required for an OSI that can serve as a basis for development of checklists, databases, and other preparation activities.

Technology presentations and discussion focused on three major areas: phenomenology, synergy, and specifications. Common themes surrounded all three sessions. For the purposes of the OSI Operational Manual, each geophysical technique (as defined by paragraph 69, Part I of the Treaty Protocol) must be tied to one or more physical phenomena. Such ties need to be clearly described and limits be defined, especially with respect to natural geological variation that can be expected at the vast variety of potential sites to be encountered. Although the technology for each geophysical technique is mature, its particular application to OSI needs is not. Procedures for its application and specific features of the off-the-shelf equipment, its application software, and details of the survey parameters need to be developed before equipment specifications can be prescribed, especially with regard to the limitations (number of inspectors, time, logistics, etc.) prescribed by the Treaty. The concept of synergy, as discussed in this workshop, involves both the integration of different OSI techniques as well as development of an optimal, logical, and defensible search strategy. During development of the OSI Operational Manual, Working Group B should recognize there is a need to specify when synergy will be used and how it is integrated with the overall scheme of an inspection and the inspection logistics. In the workshop, papers illustrated the effects of underground explosions on surrounding material that help provide guidance for the application of technologies. Other presentations illustrated results from an OSI-like geophysical survey over a former peaceful underground nuclear explosion site and practical results from industry standard geophysical surveys that demonstrate typical OSI continuation phase activities.

A useful discussion was held on the method of work and how future workshops can be structured in order to better aid the development of the Operational Manual. Recommendations for future workshops include the use of parallel sessions, drafting groups, reviews of previous recommendations, and more specific focusing on certain issues.

Contents

Introductory Remarks

Dr. Vladimir Krioutchenkov, Director of the On-Site Inspection Division of the Provisional Technical Secretariat (PTS), opened the workshop and welcomed the participants. He relayed a brief note of welcome and wishes for success from the Executive Secretary of the Provisional Technical Secretariat, Ambassador Wolfgang Hoffmann. Dr. Kriouchenkov introduced the co-chairmen of OSI Workshop-5, Dr. Vitaliy Shchukin and Dr. Alwyn Davies. He then introduced Mr. John Mabberley, Manager Director of Commercial Programs of the Defence Evaluation and Research Agency (DERAtec), the U.K. organization which hosted this workshop.

Mr. Mabberley welcomed the group and wished it good luck and success and stated that DERA was honored to host this first OSI workshop to be held outside of Vienna. He gave a brief description of the defence and technical work carried out by DERA and noted parallels between the type of work DERA is concerned with and many aspects of an OSI. From its involvement in support to military and other operations DERA has learned that an OSI cannot happen effectively without thorough preparation and readiness in logistics. He applauded the group for recognizing that broader systems engineering issues, rather than an emphasis on individual detection methodologies, will be a major concern in preparing for the OSI regime. DERA's own experience and that of it's U.K. partners tells them that systems considerations should also embrace matters of practical operability, cost-effectiveness, test and evaluation, and training.

Dr. Shchukin introduced the programme and cast it as a continuing process to advise Working Group B on OSI capabilities and techniques. He noted that the first OSI workshop, held in August of 1997, contributed much to the main elements of OSI. Since then, the workshops have become more and more focussed on the OSI Operational Manual. He expressed his gratitude to DERA for hosting this workshop. As recommended by Workshop-4 and adopted by the ninth session of Working Group B, the two main topics of this workshop were to be: **Logistics for the Pre-Inspection Period and Further Examination of Technologies for Initial and Continuation Periods of an OSI**. The main objective of the workshop is to produce proposals or guidance for the OSI Operational Manual, specifically Chapter V, sections A, B, and E and Chapter VI. He then introduced the Subject Leaders and Rapporteur.

Dr. Davies made a formal welcome to the workshop participants on behalf of the United Kingdom government and gave a formal thank you to DERA for hosting the workshop. He emphasized the importance of the PTS-sponsored OSI experiment in Kazakhstan for the purposes of OSI Workshop-5, especially the lessons learned from the experiment related to logistics of the pre-inspection phase of operations. For the experiment, the PTS assembled a team of "only" 12 people with limited equipment. Even with this limited cadre, advance preparation, and excellent cooperation from the Kazakhstan government, many difficulties were encountered in carrying out the actual field exercise. Davies pointed out that the situation could be even more difficult for the case of a real OSI. He emphasized that the time scales of the treaty will be difficult to meet unless special procedures, such as use of an advance party and/or standing arrangements, are put in place. He finished by pointing out that this workshop has incorporated more time for discussion—an especially important part of the workshop—and he encouraged participants to take part in the informal discussions and to try to come to some kind of agreement on the sessional topics.

Dr. Kriouchenkov briefed the group on progress and current tasks of the CTBTO OSI major programme. The current tasks of the OSI Division can be grouped into three major categories:

methodology and documentation projects, training and operations projects, and OSI equipment projects. Among the important activities under methodology and documentation are support of active development of the OSI Operational Manual, support of OSI workshops, and support of OSI seminars, experiments, and infrastructure databanks. Training and operations projects include introductory training courses, tabletop exercises, advanced courses, and concept and design development of the Operations Support Center (OSC). In the OSI equipment area, he briefly addressed the status of procurement of passive seismic, gamma, high resolution gamma, and xenon gas sampling equipment. Also included were an outline of the testing programs being developed and issues related to development of a testing and storage facility. He summarized the activities conducted by the OSI Division during 1999 and presented several photographs from the recently-completed OSI Kazakhstan experiment.

SESSION A:
LOGISTICS FOR PRE-INSPECTION PERIOD: FROM OSI REQUEST TO POE

Sessions A.1 and A.2 :

These two sessions were divided into two separate elements – **The Movement of Equipment, Supplies and Inspectors to the POE and the Inspection Area**, and **Standing Arrangements, Inspection Preparation and Initial Planning Requirements**. The Subject Leaders for these two elements were Judith K. Schroeder (United States) and Olivier Boulard (France), respectively.

The purpose of these two sessions, as for the other Workshop-5 sessions, was to continue to discuss issues that would assist in the development of the OSI Operational Manual – in this instance, logistical and operational issues. Specifically, Workshop participants would provide recommendations to Working Group B experts for their consideration and approval. The presentations and papers provided during this session were :

1. Essertel, G., France, "Visual Observation Support ." (CTBT/OSI/WS-5/PR/15).
2. Dewez, Patrick, PTS, "Kazakhstan Experiment Logistics." (CTBT/OSI/WS-5/PR/4).
3. Boulard O., France, "Logistics for the Pre-Inspection Period from the OSI Request to the POE." (CTBT/OSI/WS-5/PR/21).
4. Lederman, I., PTS, "Status of OSI Inspectors." (CTBT/OSI/WS-5/PR/3 and Addendum)
5. Caillou, F., France, "Possible ISP Logistical Support During an OSI" (CTBT/OSI/WS-5/PR/22).
6. MacLeod, G. et al., (United States) (paper only), "Inspection Team Logistics and Support Requirements for the Initial Phase of an On-Site Inspection." (CTBT/OSI/WS-5/PR/9 and Addendum).
7. Salcedo, L. et al., (United States) (paper only), "Pre-Inspection Activities for the Conduct of On-Site Inspections." (CTBT/OSI/WS-5/PR/8).
8. Smirnov, V., Russian Federation, "Planning of OSI Operations at the Phase of Arrival at the POE." (CTBT/OSI/WS-5/PR/16).
9. Ghosh, A., Canada, "A Proposal for Standing Arrangements for Inspectors/Inspector Assistants and Equipment via Agreements with States Parties." (CTBT/OSI/WS-5/PR/6).
10. Stokes, P., PTS, "Developments Needed to Mobilize an OSI Based on the Kazakhstan Experiment." (CTBT/OSI/WS-5/PR/23).
11. Dewez, P., PTS, "Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources for the PTS (in particular for OSIs)." (CTBT/OSI/WS-5 /PR/31).

Discussion Summary

Subject Leader Schroeder initiated the discussion with a brief introduction of the objectives for the two logistics sessions. Both logistics sessions were extremely fruitful, reflecting the most extensive discussion of logistics issues to date, and they were well-balanced with respect to the number of formal presentations and periods for discussion—a format that should be used in future workshops. The recently-concluded PTS-led OSI Experiment in Kazakhstan (with reports on lessons learned from the experiment provided by Stokes and Dewez of the PTS) provided an excellent focus for discussion and validated many of the concerns about logistics raised in previous OSI workshops, many of which will be reflected in the recommendations that follow.

Using overflight as an example, Essertel stressed the need for preplanning as well as the consequences related to logistics unique to OSI equipment, such as the choice of aircraft for overflight and consequences of the overflight inspection strategy on consumption of the allowed 12 hours of time. He also highlighted the health and safety aspects of an OSI and the associated logistical consequences. Such concerns involve the requirement to ensure that every precaution is taken to protect individuals against possible exposure to contaminated areas and equipment. A proposal for having two decontamination teams (one for personnel and one for equipment) was presented and discussed. When these teams should be present in the inspection area and whether they are part of the inspection team or provided by the inspected State Party (ISP) are important issues needing further discussion. If they become part of the Inspection Team they would impose a further demand on the already constraining figure of 40 team members at any one instant at the inspection area. During the discussion, participants agreed that WGB should determine "when the clock stops" in the overflight time account.

Dewez presented a detailed briefing of the experiences and lessons learned during the PTS-led OSI experiment in Kazakhstan in October 1999, including both equipment and personnel issues. The briefing provided the foundation for very beneficial discussions regarding the multitude of logistical details that the PTS must address in the early planning and deployment stages of an OSI, either as part of the OSI Operational Manual or as part of internal operating procedures. It was noted that many of these preparations could be identified and addressed by the use of standing arrangements with the national authorities, or other appropriate entities, of the States Parties. One of the most important lessons learned is that the current administrative and financial procedures of the PTS are not adequate for conducting an OSI. Large amounts of money (estimated to be several $M) need to be set aside in possibly a special fund and the OSI division. In its preparation following an OSI request, the TS must have the ability to use these funds immediately in the pre-inspection period in order to effectively meet the rigorously demanding timelines set out in the Treaty. Additionally, if the inspection team members do not arrive at the point of entry at the same time, there must be some agreement on the meaning of "upon arrival of the team" with respect to when the "clock starts" as specified in Treaty-mandated timelines.

Building on previous workshop discussions on the topic of standing arrangements, Ghosh presented a proposal for such arrangements with States Parties for inspectors/inspection assistants and equipment. He also reinforced the need to define the qualifications and experience required for inspectors and inspection assistants and to have a training program that certifies inspection team members. A proposal for a training program was presented that included the two categories of "general" and "specialist training" as well as periodic refresher training (for example, every three years). The discussions revealed that there is a necessity for WGB to clarify the certification process for candidate inspectors with respect to the advanced training. It was noted that a distinction needs to be made between pre- entry into force (EIF) and post-EIF periods. Some participants also noted that the responsibilities required of a State Party (SP) may not obligate a standing arrangement to confirm such responsibilities since a SP is already committed to such arrangements, especially if they are stated in the CTBT and its Protocol and/or described in the OSI Operational Manual. Other participants emphasized that such standing arrangements initially should be of a practical nature to reflect the necessary technical and logistical details that would facilitate an OSI, rather than being only a legal instrument. There was agreement that a next step should be to draft a model agreement from which to base future discussions.

Subject Leader Boulard began the second logistics session with a presentation about the necessity for standing arrangements pertinent to inspection preparation and initial planning requirements. He stressed the importance of standing agreements to accommodate the short preparation time for an OSI, to accelerate the execution of the initial OSI activities, and to provide a framework of determining the level of ISP support. To assist in developing the logistics elements of the OSI Operational Manual, Boulard proposed that it is necessary to determine: (a) what is in the Treaty, (b) what is not in the Treaty but is necessary, and (c) what is not in the Treaty but is desirable. He also addressed the problem of the liabilities and responsibilities between the Technical Secretariat (TS), the inspection team (IT), and the ISP. Lastly, he noted that the OSI Operational Manual needs to include a process for financing the preparations for the inspection and activities during the inspection.

Lederman introduced his presentation by highlighting the issues to be addressed in determining the status of inspectors and inspection assistants. The purpose of his presentation was to suggest procedures for identifying the inspectors, determining how they are designated, and specifying what qualifications they should have to become inspectors. Mr. Lederman also analyzed the meaning of the status of inspectors, including their legal standing, commitment to the CTBTO and to confidentiality, and the commitment of nominating States Parties. He also addressed the issue of reimbursement arrangements and presented several options regarding salaries and compensation. Subsequent discussion noted that flexibility must be included when the criteria for selection of the inspectors or inspection assistants is considered, since criteria that are too strict could limit efficient selection of a suitable inspector. However, criteria in selecting the inspectors such as their expertise, and experience as well as concerning their certification should be maintained.

Caillou highlighted the possible options of the ISP with respect to OSI support by referring to specific provisions of the Treaty. He noted the differences between what is systematic (that is, internal to TS preparations such as selection and transport of IT and equipment) and what support is suited to the capabilities of the ISP, both minimal and desirable support. His discussion of logistical support focused on transportation, health and safety, scientific cooperation (e.g., laboratories), communications, interpreters, accommodations and food—all items that should be defined in standing arrangements. Lastly, he concluded that the financing of this support, especially for the pre-inspection activities, must be addressed to ensure ISP cooperation.

A brief introduction of two U.S. papers was presented by Subject Leader Schroeder with minimal discussion due to time limitations. However, the preliminary statements briefly addressed some of the distinctions related to the concepts of equipment checking, equipment inspection, and equipment familiarization. The concept of having an ISP liaison officer at the TS to participate in the preparation of the equipment was introduced. There were differing views about where equipment checking and familiarization for confidentiality purposes should take place (ISP territory or baseline check at Vienna), although there was agreement that the ISP could organize the equipment check however it wants in order to meet its confidentiality concerns. In discussion a distinction was made in the term "equipment checking". It can not only cover the checking to ensure that it is fully compliant with the approved equipment (a type of authenticity or compliance test) but also the checking to ensure that it is not damaged in any way and that it functions according to the desired criteria. Who does it and where these activities are undertaken could be very different in each case. Additionally, one of these papers provides sample checklists and a sample questionnaire that may assist the PTS/TS in the initial preparations for an OSI. An illustrative sample of one of the checklists and the sample questionnaire are provided in Appendix B and Appendix C. Both of these papers require further discussion.

Smirnov focused on the process of equipment checking between Vienna and the POE. He addressed the question of certification of the equipment by the TS and suggested some checking procedures to adopt.

Following up on the earlier presentation provided to stimulate discussion, Dewez expanded on the requirements needed to address radiation safety standards.The workshop considered it essential that the CTBTO has a policy on all aspects of health and safety—especially for OSIs—and that the apppropriate standards be developed. The ad-hoc arrangements for the Kazkhstan experiment should not be promulgated further. A very interesting range of views were exchanged on this issue, with the resulting recommendation (see the second recommendation below) being formulated for further discussion by Working Group B

Stokes initiated additional discussion by presenting his perspective of the lessons learned from the recent OSI experiment in Kazakhstan, highlighting the necessity for standing arrangements in the early preparations for an OSI. He provided specific examples of agreements that were reached with Kazakhstan during the planning of this experiment. Stokes also noted that there were certain topics of information which were not so readily available (e.g., weather, topography, geology) where agreements may be needed with organizations other than national authorities of States Parties in order for the PTS to gain access to the data.

A brief summary of the areas of common understanding and those topics requiring further discussion is in Appendix D.

Recommendations

Workshop participants propose the following recommendations for WGB to consider, decide upon, and make formal recommendations to the PrepCom as appropriate. The following list is ordered in priority with regard to the immediacy of initiating action, and should be discussed at the next WGB meeting.

- Request Working Group A to develop specific assistance in the development of specific administrative and financial rules that would accommodate the short timelines and requirements unique to the preparation and conduct of an OSI. Areas to be considered include, for example:
  - what preparation costs are justified before actual approval of an OSI request;
  - the establishment of a special OSI fund that would have monies immediately available for expenditure upon receipt of an OSI request;
  - expedited procedures to acquire airline tickets;
  - compensation of – and insurance coverage for – inspection team members;
  - use of CTBTO credit cards for OSI purposes only.

- Request that the PTS, on the basis of safety standards yet to be decided, ultimately develop and/or adapt overall rules and procedures for OSI-specific implementation with emphasis on pre-EIF activities (e.g. training and exercises) that are appropriate to CTBTO needs. Use of a consultant may be considered, if appropriate. However, WGB should focus, at its next meeting, on the following :

- For the purpose of standards for protection against ionizing radiation and for the safety of radiation sources, the CTBTO should apply already established standards such as Safety Series No. 115 as basis;
- The necessity and financial and administrative consequences of classifying personnel as *occupational workers*; and
- All other areas where safety standards may be required, e.g. common elements with the International Monitoring System (IMS).

❑ Request that the PTS initiate the compilation of a comprehensive list of issues (and, where known, the specific information desired) that may require standing arrangements between the TS and the appropriate functional entity. The following entities have been initially identified as candidates for such standing arrangements: national authorities of States Parties, international organizations, Vienna airport authorities, transportation companies, equipment providers and providers of calibration and testing.

The participants of Workshop-5 have identified the following issues as examples that may require standing arrangements with the appropriate entity:

- Issuance of visas (e.g., multi-entry visas or at POE);
- Quick-response transportation, to include possible chartering of aircraft, ground transport, etc.;
- Issuance of airline tickets;
- Interpreters (to the working language of the ISP);
- Providers of planning information;
- Provision of aircraft for initial and additional inspection overflight;
- Customs arrangements, particularly for experiments prior to entry into force;
- Planning information and its sources;
- Likely level of support that a potential inspected party would be able to provide;
- Arrangements for dealing with local environmental impact issues;
- Weather forcasting (possibly with the World Meteorological Office).

[note that interpretation raises the issue of whether it should be a requirement that all team members are fluent in one language. Experience from the Kazakhstan experiment indicated some problems because of different language skills of some of the team members.]

❑ Develop a list of new topics, or the next level of detail, that could be used to update the current OSI Operational Co-ordination Table (CTBT/PTS/INF.116/Rev 2), based on topics discussed at Workshop-5.

❑ Recommend that Working Group B further consider inspectors and inspection assistants with respect to the following issues:
- expertise and experience of the OSI inspectors;
- the sensitive point of the salary or the creation of a compensation allowance;
- the relationship between the inspector and/or the inspection assistant and the CTBTO;
- inspector responsibilities: rights and obligations, personal liability, liability in case of litigation, etc.

❑ Recommend that Working Group B discuss and consider adopting the following chart that draws from several Workshop presentations or papers as a basis for further discussion of OSI-related support by the ISP.

<u>Logistics Requirements for an On-Site Inspection</u>

Type of Support	Type I*	Type II**
Overflight	♦ Aircraft and crew	♦
Transportation	♦ From the POE to the inspection area (IA) ♦ Within the IA (buses, cars …) or from lodging to IA if separate areas ♦ Drivers for vehicles	♦ Over the site (plane, helicopter)
Health and Safety	♦ Medical support for illness, etc. ♦ Evacuation means (ground vehicle)	♦ Personnel (physicians and/or nurses) ♦ Evacuation means : helicopter ♦ Individual protection equipment. ♦ Radiation protection : detection devices ♦ Decontamination equipment and personnel
Scientific Cooperation and Support	♦ Documents about the IA ♦ Working area/offices	♦ Equipment : consumables ♦ Scientists, physicists, maintenance or operating personnel ♦ possibly laboratories
Communications	♦ Short-range network (< 5 km) ♦ Middle-range network (15 to 20 km) ♦ Standard phone lines	♦ Secure phone lines
Accommodations	♦ Lodging ♦ Sanitary facilities ♦ Standard meals ♦ Meeting rooms	♦ Comfortable hotels ♦ Various meals, including special-dietary meals ♦ Purified water ♦ Shelters, tents
Others	♦ Administrative matters (visa, …) ♦ Interpreters	♦ Protective service personnel ♦ Secure storage

* <u>Type I support</u> is the standard level of support specified in the CTBT and its Protocol to be provided by the inspected State Party. Without much of this support it is doubtful whether the OSI could be conducted in an effective manner and some of the timelines may not be met.

** <u>Type II support</u> is additional desirable support that the inspected State Party could provide the inspection team. This type of required support could be provided by the technical secretariat and the inspection team but it would be costly for the TS to do so and could cause many logistical difficulties.

SESSION B:
FURTHER EXAMINATION OF TECHNOLOGIES FOR INITIAL AND CONTINUATION PERIODS OF OSI

Session B.1:
Phenomenology of Underground Nuclear Explosion as a Basis for Technologies Utilization

The purpose of this session was to discuss phenomenology of underground nuclear explosions as it pertains to the application of OSI technologies. Specifically, the goal was to identify physical phenomena that lead to selection and definition of equipment to be used during the continuation phase of an OSI. Dr. Vladimir Nogin (Russian Federation) served as Subject Leader for this session. Presentations and papers given in this session were:

1. Nogin, V., Russian Federation, “General Introduction on Phenomenology of Underground Nuclear Explosion as a Basis for Technologies Utilization.”, (CTBT/OSI/WS-5/PR/17).
2. Hall, G., Canada, “Geochemical Signatures in Soils Overlying Underground Nuclear Tests.” (CTBT/OSI/WS-5/PR/20).
3. Hawkins, W., United States, “Underground Explosion Phenomena and Inspection Procedures.” (CTBT/OSI/WS-5/PR/10).
4. Le Garrec, S., France, “Geophysical Signature of an UNE.”, (CTBT/OSI/WS-5/PR/19).
5. Belyashov, A., Kazakhstan, “Studying the Effects of Underground Nuclear Explosions on the Environment Taking as Example the Alteration of Velocity Section and Surface Morphology (Data from Semipalatinsk Test Site).” (CTBT/OSI/WS-5/PR/14).
6. Smith, A., United States, “Case Studies for the Detection of Subsurface Cavities Using Active Seismic Methods.” (CTBT/OSI/WS-5/PR/11).

Discussion Summary

In his presentation Subject Leader Nogin pointed out that it is desirable to have a physical-mathematical model for the formation of anomalies of different geophysical and geochemical fields arising from nuclear explosions in order to select the most effective set of OSI methods and for planning the execution of an inspection. He proposed a two level structure for theoretical support of the OSI methods:

- Use of complex numerical codes for calculation of irreversible variations in a medium
- Calculation and evaluation of models of anomaly formation by individual methods based on the above.

As an example, Nogin showed the results of calculations of the rock damage fields for different geophysical conditions. The second part of the presentation covered general parameters (amplitude, size, time of existence) of physical field anomalies obtained from analysis of experimental data on nuclear explosion effects with respect to OSI geophysical technologies.

The presentation by Hall concerned application of a geochemical method which uses selective leaching and dissolution to analyze only those components of the soil which scavenge volatile or “mobile” elements moving through it. These include manganese oxide films or nodules, amorphous iron oxides, aluminium oxides and carbonates. The technique involves collecting and analyzing a large number of samples. The strength of this method is that it can be used long after (months, years) the underground nuclear explosion (UNE) has occurred and the geographical limits of the suspected event have been defined to within about 10 km^2. Data from a limited experimental study from areas in the vicinity of a small number of underground nuclear explosions at the Nevada Test Site were presented and discussed.

Hawkins in his presentation pointed out that a general knowledge of underground nuclear explosion phenomena and engineering procedures forms a basis by which inspectors can recognize and document the anomalies and artifacts they produce. While some evidence of testing can be removed or concealed, irreversible damage of geological media and some residue will persist. He also described some characterisation procedures for specific visual phenomena. The following are some key observations that he related to the workshop:

- Identification of anomalous phenomena requires determination of their potential origin (whether natural or man-made) and age relative to the event of interest.
- Procedures used must allow for flexibility to address variable conditions from different sites, but also be detailed enough to ensure acquisition of useable data (equipment dependent).
- The applicability to OSI of visual observations is not unique to nuclear explosions but can guide other OSI techniques and aid data interpretation in a synergistic analysis.
- Visual observation (especially geological characterisation) is very important for the continuation period geophysical techniques.

The presentation of Le Garrec focused on the geophysical signature of underground nuclear explosions relevant to the second phase of an OSI. In the vicinity of an underground nuclear explosion, the extent of the damage zones (chimney, crushed zone, etc.) are usually expressed in terms of cavity radius, which in turn depends on the yield of the explosion. The relationships between cavity radius, depth of burial, and rock types were shown for three different yields: 1, 5, and 10 Kt. The extent and characteristics of these zones are analyzed on the basis of the French experience at the Mururoa Test Site. In addition, surface spalling phenomenon and the resulting settlement were presented. This description gives guidelines for area searches and use of geophysical equipment in the second phase on an OSI.

Belyashov pointed out in his presentation that in order to make OSI more efficient, there must be an understanding of the effects of an underground nuclear explosion on surrounding rocks and morphology of the surface. The Institute of Geophysical Research (being part of the National Nuclear Center of Kazakhstan) has been conducting studies into the impact of nuclear explosions on the blocks of earth crust at Semipalatinsk Test Site during recent years. The presentation included examples of studies of the effect of underground nuclear explosions on the earth surface and seismic parameters of the earth crust. The presented material showed how seismic sounding revealed regions of attenuation caused by the explosion that could help locate the cavity, and how seismic methods can be used in combination with other techniques to facilitate higher quality of the OSI.

Smith presented case studies from both resonance seismology and reflection seismology that illustrate the detection and location of a possible cavity. These studies include examples from field observations and outline the simplest field methods to detect a possible subsurface cavity and rubble zone. Direct detection of deep cavities using 2-D seismic reflection profiles has not been verified. However, "shadow zones" are detected using ratios of amplitudes of reflection from a geologic bed above a salt cavity at 500 m depth relative to a deeper reflection. Resonance has been detected from near-surface cavities (less than 30 m deep) within a homogeneous environment using active sources. In the heterogeneous geology 30 m above a coal mine, the method failed to detect a resonance in one study. Using passive background seismic noise, Russian researchers detected resonance by observing spectral behaviour above a cavity within salt, 800 m below the surface. These methods offer the possibility that a cavity could be detected with the same equipment proposed to be used for passive seismic monitoring during the OSI initial phase. However, limitations of this method and false alarm rates are not fully understood. Preliminary guidelines for application of these methods can be drafted for the Operational Manual by using the information from the referenced studies and as well as evaluations incorporating data previously acquired near an underground nuclear explosion for other purposes.

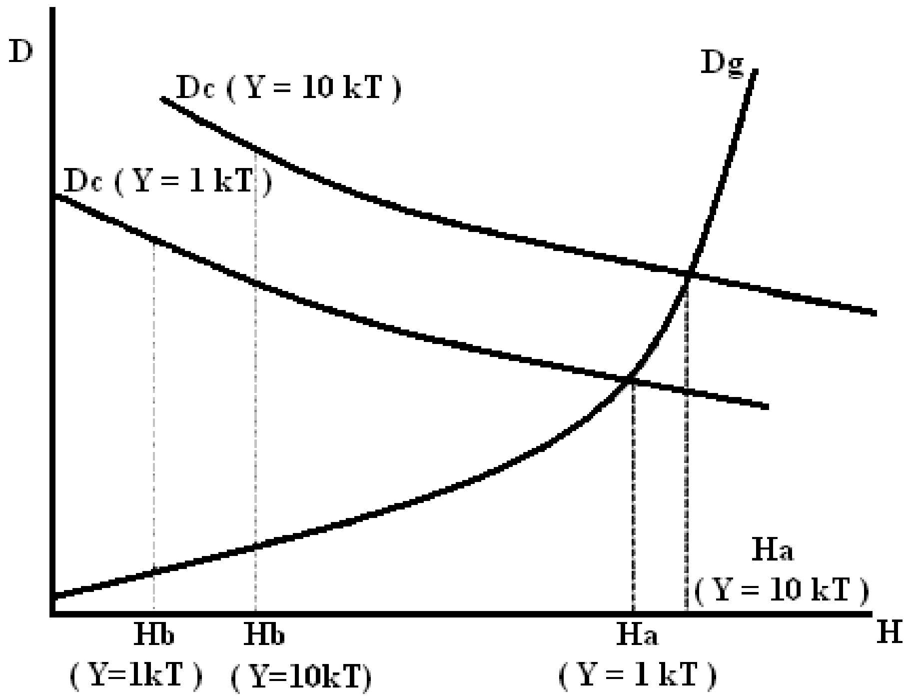
Discussion for this session mainly focused on issues involving application of additional geophysical techniques during the continuation phase of an OSI. Some participants felt that the true utility of the continuation phase methods still needs to be demonstrated; others felt that the geophysical methods are mature, but specific configurations of these techniques for OSI application need to be further developed. Of particular concern is the separation of methods into those that mainly look for shallow (less than about 100 m) phenomena versus methods that look for deeper effects related to cavity, rubble chimney, and/or melt puddle development resulting from an underground nuclear explosion. One concern expressed was that the cause of any shallow anomalies will always be ambiguous and difficult to associate directly with evidence of an UNE. However, another participant pointed out that the signature of a buried metallic vertical well casing will be quite distinct as a shallow, high spatial frequency magnetic anomaly. It was also pointed out that Le Garrec’s presentation showed that the rubble chimney can take on various forms that may not always be predictable and, short of developing a surface crater, collapse may come very close to the surface. In the latter case, the IT will want to apply any shallow geophysical method, including active seismic methods, which may be able to detect the rubble zone.

As noted above, the passive resonant seismic methods described in the presentation by Smith could be carried out with the equipment already prescribed by WGB for application to passive seismic monitoring during the initial phase of OSI. No new equipment needs to be prescribed for this application; so all that remains to be done for this technique is to define specific procedures for deployment and data analysis in the Operational Manual.

The papers of Nogin and Le Garrec are complementary. While one approach utilises very detailed calculations using specific physical models (Nogin), the other approach (Le Garrec) applies empirical relations with relatively simple algorithms based on more detailed modeling and observation. During the discussion, Dr. Kriouchenkov produced two sketch diagrams, shown below, that serve as a guide to the application of certain aspects of phenomenology. Some estimate of the yield of the suspect event will be available from the seismic magnitude determined by the International Monitoring System (IMS). The yield constrains the possible diameter of the cavity and damage (anomaly) zone and the depth of burial needed to prevent obvious surface subsidence (Hb). The curve Dg suggests the conceptual limit of the geophysical detection of the damage zone for a given method. Thus depths of the target zone for investigation would lie somewhere between Hb and Ha in the following diagram.

Diagram 1:

Area of application of a geophysical method for an underground cavity search



H – depth of burial (distance from ground zero to working point)
Dc – diameter of nuclear explosion cavity as function of H for specific yield Y (kT), type of rock, saturation conditions, etc..
Dg – minimal diameter of an underground anomaly, detectable by a geophysical method (e.g. resonance seismic) for that type of rock
Hb – 'breakthrough' depth as a function of Y (chimney zone approaches the ground surface – clear evidence of a test)

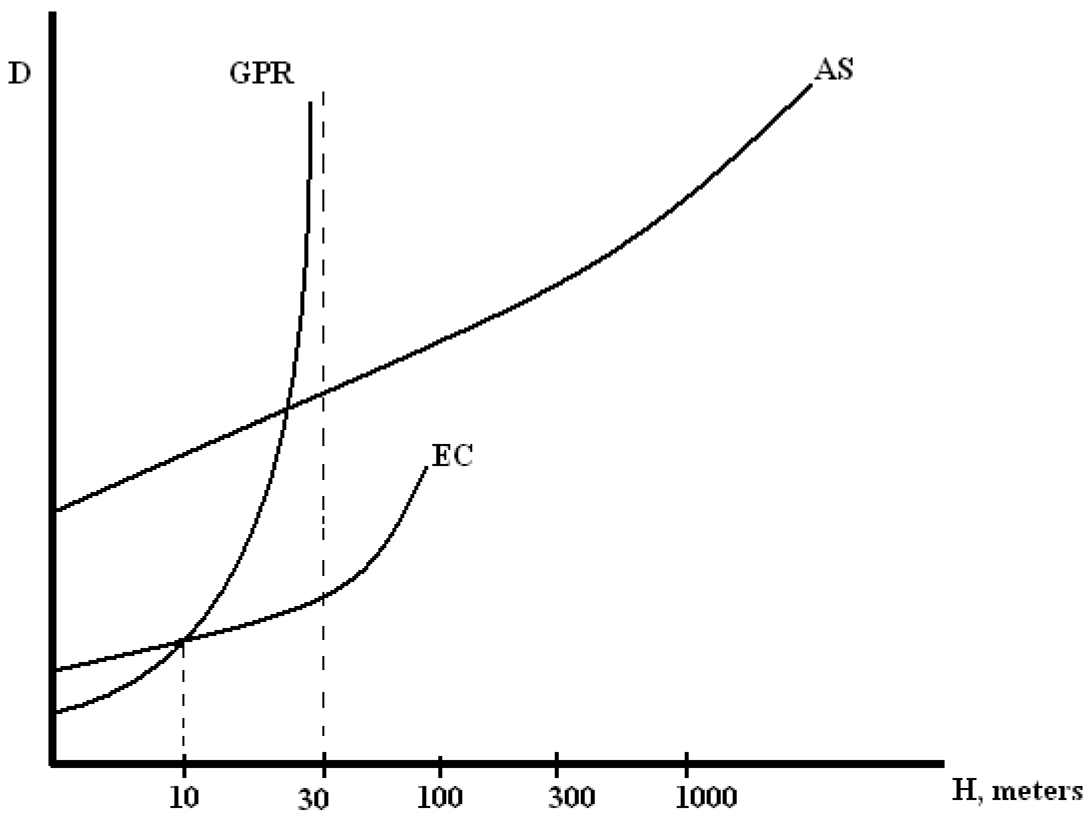
Hb < H < Ha range of depth (area of application) for application of the geophysical method

Note: for uniform ground and Y ~ 1 – 10kT, Ha ~ 5 Hb

The second diagram produced by Dr. Krioutchenkov illustrates areas of application of three different geophysical technologies for search of an underground anomaly. This diagram is based on the discussion about relationships between phenomenology of underground anomalies and utilization of specific technologies for search of the anomalies. Note that the depth scale is an approximation based on average geological conditions.

<u>Diagram 2:</u>

Dependence of detectable size *D* of an underground anomaly on depth of burial H for different geophysical methods



GPR – <u>Ground Penetrative Radar</u>: high resolution for H _ 10m, but not applicable for H _ 30m

AS – <u>Active Seismic method</u>: useful for greater depth than other techniques

EC – <u>Electrical Conductivity measurement</u>: applicable up to H ~ 100m, but resolution is lower than for GPR at H < 10m

Discussion of the geochemical methods presented by Hall centered around the needs for chemical separations and precision mass spectrometry required by this technique. Participants generally agreed that, while the technique shows some promise as a method to locate the source of an UNE, many questions remain about practical application during an OSI, specifically the frequency of sampling, the time -dependence of the phenomena, and the equipment and associated specialized personnel needed. These questions, in particular the difficulties related to field-based operation of equipment, led participants to agree that this technology is not yet ready for application to an OSI.

<u>Recommendations</u>

- The group noted several interesting presentations on the application of geophysical techniques to the continuation phase of an OSI. The techniques are most suitable for application over a search area narrowed to a few square kilometers. The group noted that these techniques can be labor intensive, time consuming to deploy, and require considerable data analysis and interpretation. In addition, because of the natural variation to be expected in subsurface conditions, it is difficult to impossible to predict in advance how effective the application of a given technique will be. The group recommends that there should be further discussion of these technologies with respect to the following issues:

  - What is the objective for application of a given method,
  - What is the range of application and what are the expected parameters of a relevant anomaly (dimensions, amplitude, time of existence, etc.); these issues should be reflected in the OSI Operational Manual.

- The Operational Manual should include precise descriptions of the phenomena to be investigated by each geophysical technique and detailed procedures for application of each geophysical method (recommended spacing of sensors, sensitivity, type of source energy, etc.).

- Data on phenomenology of underground explosions conducted in a variety of geological environments should be considered for inclusion in any OSI-related databases.

- The group welcomed the research and development work currently being undertaken by several organizations or institutes on these techniques and encourages these to be continued and their developments reported to WGB at the appropriate time. Consideration should be given to those engaged in this work to focus on identifying the appropriate technique and equipment for various environments relevant to OSI scenarios and the results be reported to WGB at the appropriate time. Furthermore, field demonstration of efficient OSI techniques may be considered where appropriate within the framework of future training programs.

Session B.2:
Feasibilities, Requirements for Application and Concepts for Synergy

The purpose of this session was to further study how to apply various OSI techniques independently or synergistically in a reasonable and effective way to achieve the purpose of inspection under the constraints of the timeline and all other provisions of the Treaty. Dr. Li Hua (P. R. China) served as Subject Leader. The papers and presentations of this session were:

1. Li Hua, P. R. China, "Introduction on Feasibilities, Requirements for Application and Concepts of Synergy." (CTBT/OSI/WS-5/PR/18).
2. Bougeois, C., France, "Requirements and Methodology for the Measurement of Radioactivity Using an Airborne/Carborne Gamma Radiation Monitoring System."(CTBT/OSI/WS-5/PR/25).
3. Rockett, P., United States, "Multi-Spectral Imaging Under a CTBT OSI: Utility, Definition and Specification.", (CTBT/OSI/WS-5/PR/12).
4. Rockett, P., United States, (paper only) "A Helicopter-Based Demonstration of Hand-Held Photography for OSI Overflight." (CTBT/OSI/WS-5/PR/13).
5. Sakharov, Y. A., et al., Russia, "Algorithm for OSI Technologies Application." (CTBT/OSI/WS-5/PR/27).
6. Kaplan, Y. A., et al., Russia, "The Experience of Experimental Application of OSI Geophysical Technologies." (CTBT/OSI/WS-5/PR/28).
7. Popov, S., et al., Russia, "The Use of Portable Noble Gas Analyzer "PANG-03" for Determination of Radioactive Xenon Isotopes in Soil Gas for On-Site Inspection." (CTBT/OSI/WS-5/PR/5).
8. Huver, M., and G. Brachet, France, "High Resolution Gamma Spectroscopy Combined with A Reliable and Efficient Software-Based Blinding." (CTBT/OSI/WS-5/PR/26)

Discussion Summary

Subject Leader Li Hua first briefly reviewed all relevant discussions on the subject matter of this session that have been covered in previous OSI workshops. The general logic of sequence of activities outlined in the third workshop would be the basis for further consideration on concepts of synergy. In his presentation, the purpose of synergy is to raise the efficiency of inspection activities so that the IT can narrow down the search area more quickly and focus on the most relevant part of the inspection area to find the ground zero site of an explosion, in the case of noncompliance. Efforts were made to define more specifically the concepts of synergy and procedures to put the inspected area into different categorized areas of interest as well as criteria for application of each technique.

Bourgeois in his presentation described a an airborne or vehicle-mounted gamma radiation monitoring system widely used in cases of accidents to find contaminated areas or lost radioactive sources. He stressed practical requirements and showed how factors such as surface radioactivity level, gamma ray energy, flight speed, flight offset, acquisition position, altitude, and sampling time influence each parameter. Detection limits were discussed according to practical considerations, in particular the background. If interesting zones were to be identified during the initial overflight, final narrowing could be performed in 7 hours for an area of 40 km^2. The survey could be also be conducted for safety. A team of experts, well trained on a regular manner is needed to perform such experiments.An important conclusion is that for effective detection of radioactivity by an airborne system, the above parameters should be chosen carefully based on experimental experience. If the radionuclides monitored and the level of detection for the system are known in advance, the efficiency of measurement could be enhanced.

The first presentation given by Rockett illustrated the utility and capability of present multi-spectral imaging (MSI) techniques in an OSI. Examples were shown where MSI, in particular the near infrared band, could discern evidence of human activity that were not obvious to the unaided eye. Rockett suggested that a 5-10 channel system would probably be adequate for the purposes of OSI, but further work is needed to define, select, and test appropriate instrumentation and determine specifications. For efficient application of MSI, significant training is needed for data acquisition, processing, and analysis. As with any data collection system, data collected in images may contain information irrelevant to the purpose of the OSI, and therefore need to be in appropriate custody with prescribed procedures. Rockett's second paper illustrated practical experience and lessons learned from a helicopter-based demonstration of hand-held photography for an OSI overflight; in particular, hand-held still photography was found to be far more useful than either stabilized or unstabilized hand-held video.

The presentation of Sakharov gave criteria for selection of high-priority technologies used in the search and location of geophysical and radionuclide anomalies created by a nuclear explosion. The criteria are applicable to different types of explosions. Information about an inspection area is of crucial importance for selecting the optimal set of technologies for each specific OSI. Selection of high-priority technologies should take into consideration the twelve most likely situations in inspection areas which take into account the time that the attributes of a nuclear explosion persist, the geology of the inspection area, climate environments, terrain of the area, etc. Visual observations and overflights take up a big share of each search phase in most of the situations. However, because quantitative characteristics of most factors influencing the characteristics of anomalies and, respectively, the selection of priority technologies, are unknown, selection is complicated and requires further discussion. Nevertheless, the list of top priority techniques for ground monitoring can now include airborne gamma spectroscopy, ground-level gamma spectroscopy, and radon sampling of subsoil gases. The high probability of emergence of a subsoil radon anomaly and the efficiency of the tehcnology used for its detection are the facors determining the advantage of this technology over potential survey technologies that rely on subsoil geochemical gases and non-gaseous chemical elements. The application of the combination of these three technologies: high resolution gamma spectroscopy and beta-radiometry using internal filling counters and beta-gamma coincidence counters makes it possible to solve the problem of identifying radionuclide anomalies and acquiring data to determine the nature of the explosion.

Kaplan described experimental applications of OSI geophysical techniques performed in Russia at a former peaceful nuclear explosion (PNE) site. The techniques that were applied included: gravimetry, electrical conductivity measurements, magnetometry, and resonance seismometry. The survey was designed specifically to simulate a real OSI by carrying it out in a field environment resembling as closely as possible environments of future inspections. The survey was carried out under a tight schedule, with a limited number of field personnel and careful account was made of the logistical procedures. The survey demonstrated positive results. He proposed that former peaceful nuclear explosion sites provide excellent sites for international OSI experiments and candidate inspector advanced training.

In Popov's presentation, a portable instrument system for radioactive noble gas sample preparation, measurement, and analysis was introduced; the system has small weight and size, and is made up of separate units which facilitate transportation and assembly. The availability of portable noble gas detection equipment is highly desirable for field operations. The minimum detection concentration under certain circumstances defined in the paper is about 1.1 mBq/m^3 for ^{133}Xe and 1.6 mBq/m^3 for ^{135}Xe (with probability 0.84). Further improvement to the system was proposed and will be carried out.

The presentation of Huver reviewed the importance of gamma spectroscopy techniques for sampling and analysis for an OSI. A lot of radioisotopes are gamma emitters, and field spectroscopy with high purity germanium detectors is of great interest to OSI for interpreting contributions of isotope from the approved list. Removal of the contribution of natural isotopes and discrimination between isotopes with close characteristic energies can be performed with modern software. Consequently, means exist for solving the foreseen issues of measurement restrictions in strict respect of confidentiality. An example was shown comparing results of a synthetic spectrum provided by a germanium detector with a real spectrum from NaI detector applied to the current OSI list of radionuclides. The poor resolution of NaI detector makes it obvious that blinding in this case is not necessary. In the field, quantification of the activities of the detected isotopes could be the object of additional measurement by determining the ratio between specific isotopes, in order to discriminate from events not relevant to the Treaty purposes.

During the discussion the Russian representatives who have carried out the surveys at former PNE sites pointed out that it is important to have a common understanding of the capabilities and comparative labor cost of inspection techniques at the time of inspection planning. In particular, Russian participants suggested that geophysical techniques need substantially smaller labor expenses, contrary to what was presented in this workshop and what has been presented for certain techniques in previous workshops. Therefore, the issue requires further consideration.

While recognizing the importance of adopting a synergistic approach whenever possible, it should be remembered that the techniques that can be used during the various periods of an OSI are "tools in a tool box" and that the inspection team leader should use what he sees appropriate at a given time in the inspection. The concept of flexibility in the choice of the "tool " was emphasized by many participants.

General common understandings on synergy:

- Each OSI technique has its own limitations and advantages when applied to achieve the purpose of an OSI. For this reason and in the spirit of relevant provisions on techniques in the Treaty, OSI techniques should be synergistically to achieve optimal efficiency and maximize the probability of a successful inspection. This is the essence of the topic of synergy.
- During an inspection, the IT usually faces many external constraints like manpower, time and a relatively large area to search. From this aspect, it is also important for the team to consider the problem of synergy. Therefore, at the same time each OSI technique is studied in depth, the topic of synergy should also be considered.
- Although there is a general understanding about the basic concept of synergy, its accurate definition and the method to be used still need further development.
- For optimal application of various OSI techniques at any given time during inspection, the inspection team always faces the same basic problem: what techniques or activities should be carried out next, where, when, and why.

- The general sequence of activities logic discussed in OSI Workshop-3 provides an example of how to address the "what" and would be conducted if a particular part of inspection area is identified with higher priority of interest. Details of the logic, and whether the selection process should be a serial or parallel process are items needing further discussion. (For example, refer to the chart shown in Appendix E which is an example, submitted the subject leader of this session, of a logical iterative process whereby the various permitted techniques for an OSI can be deployed. (There was limited discussion on this type of flow-chart approach and hence the inclusion in this report does not necessarly mean that consensus was achieved on this approach.)
- At any given time, different amounts of data associated with each inspected sub-area and the relevance of these data to the purpose will differentiate sub-areas with different priorities. This will lead the inspection team to have an idea of "where and when" to conduct further inspections. The definition of level of priority will address the question "why".
- A goal of the study of synergy is to define and develop specific methods and procedures for the development of the OSI Operational Manual.
- Further study in depth on individual techniques, such as airborne or vehicle-mounted gamma radiation measurement, xenon detection, multi-spectral imaging, and a number of geophysical techniques presented in this workshop will be very helpful for developing an understanding of their roles in the framework of synergy.
- Practical experience in the use of different techniques in combination in the field will help in developing guidelines for narrowing down the search area and will provide valuable input for development of methods of synergy, as shown by the presentation on the PNE site survey.

Session Summary:

OSI Workshop-5 considers that for development of OSI Operational Manual, it is necessary to continue to develop the method and procedures of synergy, based on general logic of sequence of activities recommended in the third OSI workshop. For this purpose, the following sub-topics should be considered,

- Tasks of Synergy
  The aim is to understand and define tasks of synergy for the whole inspection, as well as for each of three major steps: narrowing down searching area, locating possible ground zero of the site, and collecting direct evidence in the vicinity. Synergy problems and tasks may not be the same for these different steps.

- Categorization of Data
  The aim is to define more specifically the categorization of data collected in an OSI, based on results of studies of phenomena of nuclear explosions and what parameters OSI techniques can measure as well as taking into account confidentiality. On this basis, the aim is to define priority levels.

- Correlation between Phenomena of Nuclear Explosions or Features of the Inspection Area and OSI Techniques
  The aim is to further refine such correlation (as an example, see Appendix F, provided by the subject leader of this session) and to have a clear understanding of what should be measured and their sequence of application.

- Definition of Input Information for Each Technique
  The aim is to define what kind of input information each technique needs for its effective application.

- Definition of Output Information for Each Technique
  The aim is to define what kind of output information is provided by each technique, including raw data, analyzed data, and any other conclusions.

Session B.3: Equipment Lists and Specifications, and Logistics Requirements

The purpose of this session was to discuss equipment to be specified for the continuation phase of an OSI and specific logistics issues related to the use of such equipment. Dr. A. Smith (United States) was Subject Leader for this session. Papers and presentation of this session were:

1. Smith, A., United States, "Equipment Lists and Specifications, and Logistics Requirements." (CTBT/OSI/WS-5/PR/29).
2. Patel, V., PTS, "OSI Equipment Testing Programme." (CTBT/OSI/WS-5/PR/2).
3. Kumurdjian, P., France, "Impact of Daily Laboratory Experience on the OSI Equipment, the Inspectors Training Programme and the Selection of Members of an Inspection Team." (CTBT/PC-7/OSI/WS-5/PR/7).
4. Burger, P., France, "Suggested Specifications for Geophysical Equipment Used in the Second Phase of An Inspection: Active Seismic Survey, Magnetic and Gravitational Field Mapping, Ground Penetrating Radar and Electrical Conductivity." (CTBT/OSI/WS-5/PR/30).
5. Nazamov, A. Zh., Russian Federation, "Integrated Expert System for a Prior Evaluation of OSI Results." (CTBT/OSI/WS-5/PR/24).

Discussion Summary

Subject Leader Smith introduced the session and emphasized that when results are reported concerning phenomenology of underground nuclear explosions (UNEs), it is very important to state clearly how the results were obtained. Both the details of the procedures and specifications of the equipment used during the acquisition and analysis of geophysical surveys at UNE sites must be evaluated when equipment specifications are considered; the two factors cannot be separated. Most of the geophysical equipment envisioned for use under paragraph 69 of Part I of the Treaty Protocol is routinely used around the world and readily available from manufacturers. Off-the-shelf equipment, with specifications generally suitable for application to OSI, is available for ground penetrating radar, electromagnetic, magnetic, and gravity surveys, and seismic reflection surveys. It is important to state clearly any unique specifications to equipment used for an OSI, and to document any unusual procedures needed to achieve the desired performance. Smith introduced a table for comment that summarized the geophysical and noble gas measurements and their specific value during the continuation phase of an OSI. This table is reproduced in Appendix G of this report.

Patel in his presentation outlined a set of options, for consideration by WGB, for the OSI equipment testing program. These options raised questions among participants on who has responsibility for the equipment and its coordination with training. For example, if a contractor evaluates the equipment, would they be responsible for familiarization training? There are advantages in having the same people involved in both testing and training, but the uncertain schedule for advanced training precludes its linkage with the laboratory and field-testing schedule.

In the presentation by Kumurdjian, the impact of daily laboratory experience on the OSI equipment, the inspector training program, and the selection of team members was considered. The core of inspectors should have field experience with the equipment and may overlap those having experience in nuclear weapons tests, although it is recognized that the number of these will diminish with the passing of time. In addition, the expense of equipment and the need for backups suggest renting equipment along with a core of experienced users. He also suggested using the few days of the pre-inspection period to refresh equipment training for the inspectors. These latter suggestions stimulated lively comments from the delegates: backup people are needed as well as backup equipment; the IT will be too busy during the pre-inspection for an equipment refresher; and given their duties, only a few TS personnel will be available for an OSI. One participant emphasized that only minimal equipment maintenance is reasonable in the field, given the limited time and personnel. Others suggested the following: testing expertise related to underground nuclear explosions will be scarce in the future (provided the purpose of the treaty is successful) so we must capture that knowledge; drillers with relevant experience might be found from the field of environmental assessment; and mapping is a talent needed by all visual observers to describe the observed features. Trained geologists and geophysicists are key to the interdisciplinary nature of the OSI; they are trained to observe and recognize many of the features associated with an underground explosion. Drilling, for example, will be difficult without some idea of the physical properties of the rock formations being drilled.

Burger presented proposed specifications for geophysical equipment to be used in an OSI continuation phase based on his practical experience as a geophysical contractor. The methods presented included an active seismic survey, magnetic and gravitational mapping, ground penetrating radar and electrical conductivity. To evaluate these requirements, a configuration was assumed for the post-shot geologic conditions. Burger emphasized that contractors view magnetic, electrical conductivity, gravity, and ground penetrating radar as methods for investigating the upper 30 meters of the earth for artifacts. It was asserted that cavity localization would normally require an active seismic survey. Based on the technology and the desired target, Burger suggested equipment specifications and numbers of personnel needed to meet these objectives. Given that these geophysical methods are used by industry and are adequate for an OSI, a geophysical service company could perform all the required tasks without the TS needing to acquire equipment or train inspectors. Again this presentation sparked a lively discussion. It was asserted that many of the suggested equipment specifications were actually more stringent than necessary for the detection of the observed anomalies, although it was asserted that these specifications are based on common, off-the-shelf equipment used by the geophysical industry. This emphasizes the importance of documenting unusual procedures used for an OSI and their implication for the selection of equipment.

To evaluate an inspection area, Nizamov introduced an integrated expert system for *a priori* evaluation of On-Site Inspection results. The desire is to perform the primary processing of results of these geophysical measurements, to determine the characteristics of the measured fields, to evaluate the results for the presence of anomalies indicative of an underground explosion, and to develop recommendations for improving the search strategy. It was raised during the comments to the presentation that the expert system might be useful for training inspectors and for an assessment of the search, but it cannot make the conclusions. It was suggested that the system could not be used in the field under the treaty, and would have limited use in the Operations Center in Vienna since the geophysical data would not be available there.

<u>Recommendations</u>

- The TS should acquire complete, integrated equipment systems that include acquisition of data as well as production of the final result. The procedures needed by the IT to apply a specific geophysical technique should be reflected in the equipment specifications.

One option is for a manufacturer or company to be responsible for seamless integration of software. There is no question of responsibility for its functional performance to the conditions of an OSI. This might be thought of as a turn-key system. The company can do much of the basic training, would maintain integration for any upgrades, and remove any development from the TS. Maintenance is greatly simplified for the TS; consequently, fewer personnel are needed within the TS. Logistical requirements are both clarified and simplified.

Issues:
Geophysical equipment is a mature technology; improvements come as digital technologies advance acquisition. These factors, combined with improved software and algorithms for interpretation, can allow dramatic improvements in the results. These improvements continually occur within the geophysical industry. However, for the TS to take maximum advantage of this, unique requirements to OSI must be minimized; otherwise, unique development will dramatically increase the equipment expense to the TS, and ultimately make the OSI requirement so demanding that it cannot be readily met by a commercial supplier without significant modification.

The TS is not a development organization; instead it desires to optimally apply a technique to the objectives of an OSI. Subsidiary objectives include a desire to minimize maintenance, to allow for easy upgrades of the equipment, and to simplify its application by an IT. These conditions imply that software for analysis is as important or even more important than the actual instrument.

If the TS acquires separate analysis software and acquisition equipment, the issue arises of who integrates these and who is responsible for any incompatibilities. The TS would need to maintain a staff or contract the capability for this integration, which is a form of development. Any upgrades would need to be integrated as part of this development.

- Draft components of the OSI Operational Manual need to emphasize the application of a specific geophysical technique to conditions of an OSI.

Issues:
The OM must outline how an OSI application differs from “routine” use of this method. Such details are not readily available to a geophysicist member of the IT. Answers to the following questions should be considered when preparing text for the OM:
- How are equipment specifications unique to an OSI equipment, and are we asking for changes to specifications for equipment routinely available from manufacturers?
- Why are these changes needed and are they essential?
- If changes to off-the-shelf specifications are necessary, how are they achieved without a significant impact on the cost?

Drafters of OM text need to be very careful about specification of procedures needed to change performance for a specific application of an OSI technique. Are any changes to software or analysis procedures needed? What does this mean for the OM? We must document the specific differences needed in the OM.

- Our current understanding of resonance seismology is sufficient to describe the functional requirements of the seismic equipment.

Issues:
Existing specifications for passive seismic equipment satisfy basic requirements for resonance seismology as outlined in the workshop. Additional analysis software may be necessary and requires specifications. Operational limitations have not been completely defined and these require further work by States Signatories. Procedures necessary for application of passive seismic equipment will be documented in the OM.

- For the time being (prior to EIF), testing and evaluation of equipment should be independent of the training program.

Issues:
Training on equipment with its use in the field is an adjunct to field testing of the OSI equipment; actual users provide the most effective field evaluation of equipment. However, the schedule and the development of both testing and training are only beginning and it is premature to couple the two functions.

In later stages of development of the OSI regime of the CTBTO, training offers an excellent opportunity to evaluate the equipment, its ease of use in the field for inspectors, and the functionality of the software.

A current proposal on how to conduct testing and evaluation was presented at the workshop (Patel). This included how testing should proceed, who will conduct the testing, and what is being evaluated. Aspects for initial testing and evaluation include environmental performance, authenticity of data, integration of hardware and software, and ease of use in the field.

Session 5: Closing Session

The closing session included two discussions led by the two co-chairmen: a discussion on the method of work for future OSI workshops and a discussion of topics for discussion in Workshop-6. In determining the topics for discussion at future workshops, especially workshop 6, Davies proposed the following criteria for considerations:

- there must be an urgency to have the topic discussed soon rather than leave it until a later workshop
- it must be clear what is required from the workshop (in this the concept of a *product*, such as a recommendation or agreed draft for consideration for the manual, were raised)
- it must aid the PTS in developing the OSI regime

The agreed provisional topics for discussion, dates and location of Workshop-6 are given in Appendix A.

OSI workshops have been instrumental for the development and execution of OSI activities mandated by the PrepCom, WGB in particular. This is exemplified by the technical recommendations for the specifications of OSI equipment sets for testing and training purposes and other wider ranges of suggestions. For future workshops, the method of work and reports of these workshops are expected to be used even more for the development of the OSI Operational Manual. In this respect, participants of Workshop-5 recommend the following:

- Working Group B should consider whether workshop sessions should be conducted with some separate discussion and drafting groups working in parallel to increase output. Reports of future workshops should contain recommendations or even text suggestions for inclusion into draft versions of the Operational Manual that will be subject to WGB consideration.

- Future workshops should be arranged in a more flexible manner and more closely molded to the specific Operational Manual development needs, with perhaps a more limited scope, but greater depth, of subject coverage.

Acknowledgment from the Rapporteur

This document benefited from the efforts of many people. The Subject Leaders in particular—Ms. Schroeder, Mr. Boulard, Dr. Nogin, Dr. Li, and Dr. Smith—made my job easier by providing the input that formed the basis of the document. The PTS staff provided typing, editing, logistical support, and valuable comments that greatly facilitated the work of putting the report together. I would also like to thank the Workshop participants and speakers for providing the raw material for the report and providing constructive reviews of draft versions. Finally, I would like to acknowledge the excellent suppport given by DERA at the meeting, in particular Mr Ludgate and his team.

APPENDIX A

SUGGESTED TOPICS, DATE AND LOCATION FOR OSI WORKSHOP-6

The following is an **indicative list** of possible topics for OSI Workshop-6, based on a PTS proposal.The sole objective of the Workshop is to concentrate on the development of the OSI Operational Manual.

OSI Technologies, Methodologies, Techniques for Application

1. Operational Requirements for OSI Equipment

   - Additional consideration of equipment specifications for various inspection periods (taking stock of all past Workshops results) (Subject Leader - A. Smith).

   - Identification of OSI technique application areas and related phenomena (Subject Leader - V. Nogin).

   - Formulation of technology/equipment application procedures (Subject Leader - Li Hua).

2. OSI Logistics: Continued Work on Standing Arrangements, Status of Inspectors and Support Equipment Supplies (Subject Leader - J. Schroeder).*]

OSI Workshop-6 will be held from 8-12 May, 2000 in Vienna. The alternative dates (26-30 June 2000) are also under consideration.

APPENDIX B

Examples of Checklists

These checklists are examples, provided in a paper presented at this workshop, of those that could be developed (by WGB via the Operational Manual, or by the PTS) for use in OSI preparatory activities.

Title:	**Develop the Inspection Mandate**	
Check	**Action Item**	**Comments**
	Assemble IDC data	Seismic, infrasound, radionuclide
	Assemble RSP data	
	Assemble other States Parties Data	National technical means
	Assemble data obtained from consultations and clarifications	
	Decide what technologies would best evaluate the existing anomaly based on the available data*	Choose the least intrusive that will meet the requirement
	Determine the boundaries of the IA*	Not to exceed 1000 square kilometers

Title:	**Arrange for Overflight Aircraft**	
Check	**Action Item**	**Comments**
	Verify aircraft is available	Assuming ISP will provide aircraft
	Verify aircraft is suitable	Can safely transport required crew, observer, and inspectors. Provides adequate view for observer and inspectors
	Verify modifications have been made to aircraft to allow safe and effective mounting of inspector equipment	TS predetermined modifications
	Verify airfield for operation of aircraft is within reasonable distance of the IA and base of operations	Prevent unnecessary delays
	Verify fueling and ground support is available	For safe operation
	Verify navigation aids are available	Position finding, directional beacons
	Verify aircraft has communications that can be used by the inspectors	Voice communication between observers (intercom) and air to ground voice communication between observers and base of operations (radio).
	Verify aircraft has sufficient range to enable a reasonable time over the IA	Predetermined by TS

Title:	**Equipment Checks by ISP**	
Check	**Action Item**	**Comments**
	Inspect containers for obvious damage in shipment	Precursor to equipment damage
	Inspects seals on containers*	Detect tampering enroute
	Provide inventory of each container to ISP*	Greatly facilitates selecting equipment that requires checking as well as placing the equipment back in the proper container after checking
	Verify equipment is certified by TS*	Check tags and supporting documents
	Verify equipment is appropriate to inspection mandate*	Compare equipment selections to mandate requirements
	Verify equipment is calibrated to recognized standards	Check tags and supporting documents

* Indicates a treaty-mandated action.

APPENDIX C

Example of a Sample Questionnaire for States Parties

Workshop participants recognized that background information about an inspection area will be needed for planning purposes prior to conduct of an OSI. One way to obtain this information is for the CTBTO to compile a confidential database of information to be available at the time of Treaty entry into force (EIF). The following is an illustrative sample questionnaire introduced for further discussion further discussion by Working Group B or in a future OSI Workshop.

1. State Party:

2. Date:

3. National Authority Contact Information:

4. Health and Safety:

a. Description of climate and temperature ranges;
b. Description of known ecological/medical hazards;
c. List of vaccinations commonly recommended for travel within its territory;
d. Describe availability of medical treatment;
e. Availability of potable water.

5. Transportation Support Capability:

a. Description of dominant geographical features of state;
b. Description of transportation infrastructure and major highways;
c. Available options for transport of an inspection team, and its equipment within its territory. Description of air options and ground;
d. General availability of fuel for aircraft, vehicles, and generators;
e. Description of planned parking, security protection, and servicing arrangements for an IT; aircraft, if required, at the POE, and where necessary, identification of possible basing points. Describe any limitations on types of aircraft that may land at its airfields;
f. Description of emergency medical evacuation capability.

6. Support for conduct of inspection

a. List and describe any equipment (logistical and technical) that may be made available to the IT for use in an inspection area. The equipment must be in accordance with agreed specification standards;
b. Provide information on own aircraft to be used during IT overflight of inspection area, if applicable. Aircraft must be pre-equipped in accordance with technical requirements of the relevant operational manual, and crew;
c. Description of communications equipment, procedures, and regulations to be utilized by IT during an on-site inspection, if applicable;
d. Description and availability of interpretation and translation services.

7. Working conditions

a. Description of working space options to be made available to IT and observer to be used during the course of an on-site inspection.;
b. Description of housing and working facilities intended for use by the IT;

APPENDIX D

Pre-Inspection Period Logistics: Items of Common Understanding and a List of Topics Requiring Further Discussion

During Session A, Logistics for Pre-Inspection Period: From OSI Request to POE, a number of areas of common understanding were identified by the workshop participants, as identified in the first list below. In addition, a list of topics requiring further discussion was also identified; these are also presented in the second list below.

<u>Areas of Common Understanding (in random order):</u>

- Importance of logistics in the selection of OSI equipment, e.g., overflight aircraft;
- Importance of giving inspection team leader the flexibility to adapt/react to logistical challenges;
- Importance of having a mechanism to assess the completion of training and qualification of inspection team members;
- Necessity to have sufficient sets of equipment to allow for availability of pre-packaged certified equipment for OSI equipment to allow for OSI use and for training purposes;
- Necessity for development of special administrative and financial rules for conducting an OSI;
- Use of an inspected State Party (ISP) liaison officer (and selected experts, as required) in the Technical Secretariat during initial preparations and conduct of an OSI;
- Necessity for ensuring the health and safety of the inspection team, through the adoption of appropriate minimum international standards;
- Necessity of defining when the “clock starts” upon the arrival of the inspection team at the point of entry.;
- Adoption of standards for the transportation of hazardous materials, taking into account more stringent standards of a State Party;
- Necessity of maximizing pre-planned logistics:
  - Development of standing arrangements, as required, based on a model agreement template;
  - Development of guidelines for pre-packaging and storage of OSI equipment;
  - Presence of an ISP liaison officer at the TS to participate in the preparation of equipment shipment.

It is recommended that, for the above-listed areas of common understanding, WGB encourage States Signatories to supply suggested options/solutions or task PTS, as appropriate.

The following topics were discussed during Workshop-5 but require additional discussion to determine the best approach for inclusion into the OSI Operational Manual:

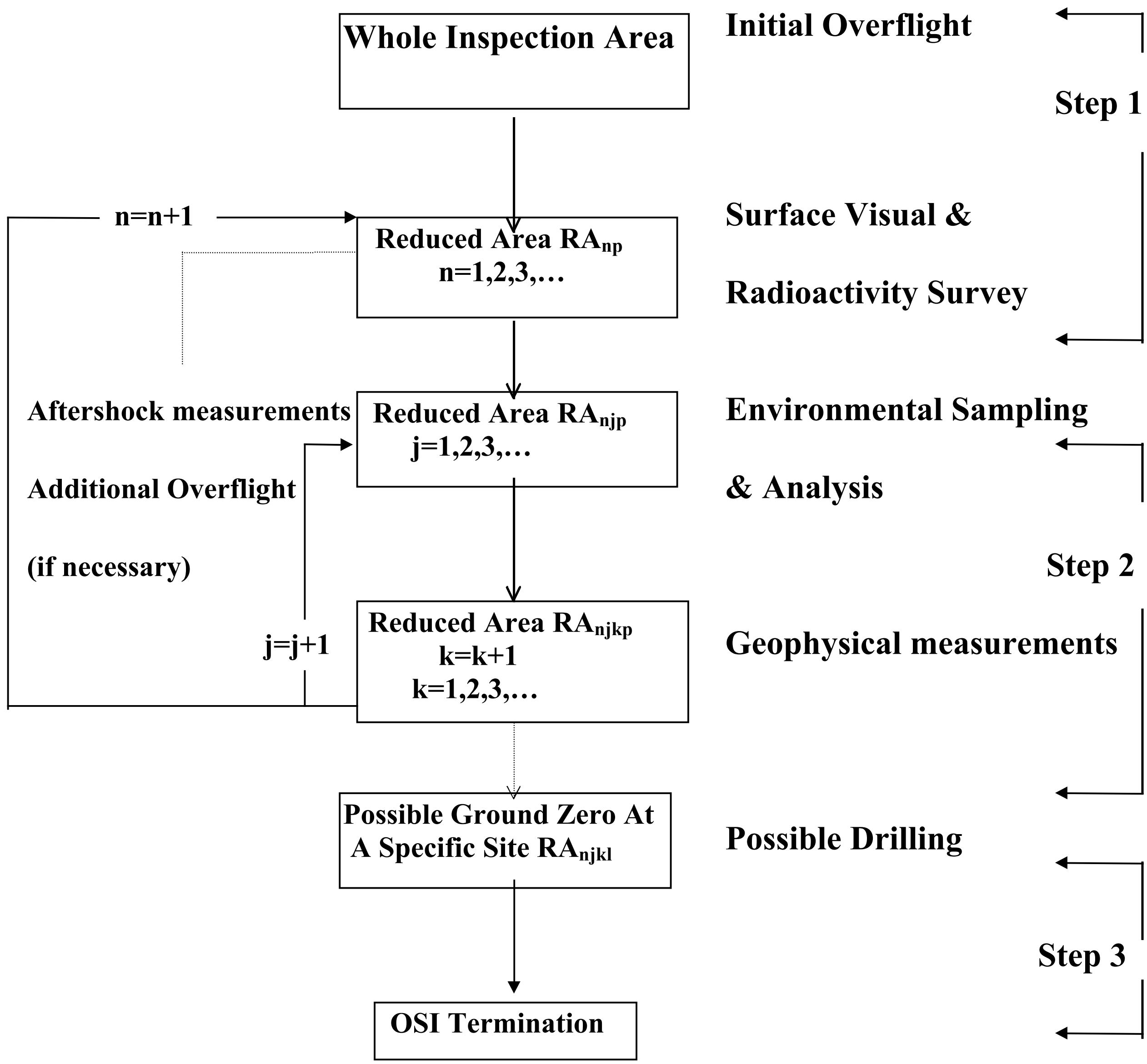
- The extent of use of decontamination teams and equipment during an OSI;
- Clarification of the meaning of “equipment checking”, “equipment inspection”, and “equipment familiarization” – and the tasks involved in each activity;
- Location where equipment checking and equipment familiarization for confidentiality purposes will take place;

- Phasing and rotation of inspection team members and OSI equipment at the point of entry. One option is shipment of key equipment items (to be defined) and inspection team members to the point of entry and inspection area before rotation;
- Designation of the inspection team leader as a "Deputy Director-General" for the duration of an OSI;
- Compensation or salary, insurance coverage, and responsibilities of inspection team members;
- Status of inspection team members, in particular their expertise and experience and their relationship with the CTBTO;
- Commitment of States Signatories/States Parties to assure that, to the extent possible, they will nominate inspectors that have been trained prior to entry into force.

APPENDIX E

Example of a Three-step Division of the OSI Process

Each Reduced Area RA_{njk} Has a Level of Priority Presented by Subscript p



APPENDIX F

Applicable OSI Techniques for Detecting Nuclear Explosion Phenomena and Inspection Area Features

IA Features & UNE Phenomena / OSI Techniques			1st Step						2nd Step							3rd Step
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
			Initial Overflight	Ground Visual Observ.	Video, Still Photography	Measurements of Levels of Radioactivity (γ monitoring)	Passive Seismological Monitoring Analysis	Multi-spectral imaging, incl. Infrared measurements	Magnetic Field Mapping	Ground Penetrating Radar	Environmental Sampling of Radioactivity	Environmental(non-nuclear) Sampling and Analysis	Measurement of Electrical Conductivity	Gravutational Field Mapping	Resonance Seismometry and Active Seismic Survey	Drilling to obtain R/A Sampls for analysis
1st Step	1	Orientation & Geography	☆	☆	☆											
	2	Culture Activity Transportation	☆	☆	☆											
	3	Man-made Artifacts	☆	☆	☆			☆	✚	✚						
	4	Surface Cratering	☆	☆	☆											
	5	Fractures and Other Surface Changes		☆	☆			☆		✚						
	6	Biological Stress and Shock Wave Damage		☆	☆			☆								
	7	Residual Radioactivity				☆					✚					
	8	Heat						☆								
	9	Cavity Aftershocks					☆									
2nd Step	10	Radioactive Slurry(water)				✚					✚					
	11	Radioactive Xe				✚					✚					
	12	Radioactive Ar									✚					
	13	Fission and Activation Products				✚					✚					
	14	Flow Change in Natural gases										✚				
	15	Geochemical Anomalies										✚				
	16	Underground Cavity and Rubble zone											✚	✚	✚	
3rd Step	17	Residual Underground Radioactivity														●

Note: stars correspond to first step activities; plus symbol refers to second step; dot represents last step activity.
If steps are used, cavity aftershocks must also be in step 2. Also, passive seismic and radioactive measurements could also be used in step 2. That is the problem with clearly defined steps.

APPENDIX G

Table Summarizing Geophysical and Noble Gas Measurements and Their Specific Value to OSI

[this table provided for comment]

Technique	Detection feasibility and prerequisites	Interfering natural phenomena	Comments
Gas Analysis			
Xenon gas analysis	-Xenon isotopes of interest decay rapidly -No field instrumentation yet -Collection (sampling) rate could be high. Analysis rate currently low (9 hrs for IMS prototype), but faster for lower OSI sensitivity (2 to 3 hrs). -total number of samples could be large (100s to 1000s) -simple,well-established collection methods -requires field team and lab team (same radionuclide team for all technologies). -rate and time of Xenon release influenced by barometric pumping		Potentially conclusive evidence for occurrence of UNE.
Argon gas analysis	-No field instrumentation yet -analysis might be conducted off-site in certified laboratory having the specific specialization for ^{37}Ar (only a small number of labs available)		- ^{37}Ar is a neutron activation product. Its presence is dependent on the amount of calcium in the adjacent rocks. -If Xe is detected, suggests analyzing for ^{37}Ar as additional evidence that is unique to an UNE. - Because of its longer half-life, ^{37}Ar may be detected in absence of Xe at longer times
Radon gas analysis	-field instruments available -relatively fast method (2 days for 1 km^2) -requires field team and lab team		Detection of disturbed ground above cavity. Natural phenomena give signature similar toexplosions.
Gamma Spectrometry	-lab team with experience in sampling required. -blinding necessary		Different emphasis in different phases: -safety of inspection team. -Rn analysis. -Xe analysis. -Radionuclide analysis.

Active Seismology: 3-D reflection seismology	-3-D may detect and locate cavity. -equipment, personnel, and processing capabilities outside the capability of TS. - use of contractors. -specialized team and logistical support. -need seismic source: explosions or vibrator truck. -pre-OSI survey helpful -blinding for shallow features may be desired		Needed to define location, especially if later drilling is necessary to sample isotopes.
2-D reflection seismology	-2-D can detect cavity in ideal conditions, but not expected at depths over 100-m. -pre-OSI survey helpful -blinding for shallow features may be desired	Karst	
Resonance	-uses existing passive seismic equipment -passive source possible using background seismic noise -more validation needed of method, procedures, and results	Karst	Detection of possible cavity, chimney, or disturbed zone.
Magnetic measurements	-proven to detect near surface artifacts (pipes, cables, etc.) -rapid reconnaissance	Basalt Rich iron minerals	Discover evidence for clarification
Gravitational anomalies	-proven for near surface structures as extension of rubble zone. -not reliable for standing cavity. -microgravity survey requires significant time. -pre-OSI database helpful	sinkholes	-Limited value if major effort required. -Terrain corrections necessary. Requires precise cm survey too. -Repeated surveys may detect continuing surface deformation above cavity.
Electrical Methods	-proven near surface tool for artifacts. -geological model helpful		
GPR - Ground penetrating radar	-proven for near surface artifacts (pipes, compaction from previous traffic, fractures, trenches, etc)	Clay beds water	High resolution at shallow depths (less than 10 m)
IR and Multispectral	-proven for surface disturbances detection -blinding may be desired -geological and geographical database would be helpful	Hot springs Landfills	Detection of recent activities on the surface